PATENT SPECIFICATION

DRAWINGS ATTACHED

1,167,729

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ıternational Classification:—**H 05** k 1/00.

COMPLETE SPECIFICATION

Circuit Board

We, TEXAS INSTRUMENTS INCORPORATED, a Corporation organised according to the laws of the State of Delaware, United States of America, of 13500 North Central Expressway, Dallas, Texas, United States of America, do hereby declare this invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrical circuit boards.

In certain applications, circuit boards are required on which components or networks (e.g. integrated semiconductor networks or so-called microminiature functional modules) are mounted with a high density of interconnections. Frequently, multilayer circuit boards, which may have as many as eight to twelve layers, are used to achieve a high package density. Such arrangements are relatively complicated to construct and require a degree of precision design and fabrication which can be uneconomical. Also, such arrangements are lacking in flexibility as regards circuit layout changes making short production runs, in particular, relative costly.

According to the present invention, a circuit board comprises a matrix of insulating material having a plurality of spaced electrically conductive terminal regions partly embedded in the matrix, selected ones of the terminal regions being interconnected by electrical leads enclosed in the matrix, which leads have individual electrically insulating coverings. In a single sided board the terminal regions have surface areas exposed at a common surface of the matrix and in a double-sided board some of the terminal regions have surface areas exposed at one surface of the matrix and the others of the terminal regions have surface areas exposed at an opposite surface of the matrix.

The invention also provides a method of manufacturing a circuit board, comprising forming a plurality of spaced electrically conductive terminal regions on a surface of a carrier with a surface area of each terminal region next adjacent the said surface of the carrier and connecting electrical leads having individual electrically insulating coverings between selected terminal regions. Electrically insulating material is then applied, e.g. as by moulding, to enclose the electrical leads and to cover the surfaces of the terminal regions other than those next adjacent the carrier and also to cover the remaining portion of the surface of the carrier to form a matrix enclosing the leads and in which the terminal regions are partially embedded. The carrier is then separated from the matrix to leave exposed the surface areas of the terminal regions previously next adjacent the carrier surface. In a specific embodiment, a weldable metal layer is applied to a carrier and a pattern formed in the metal to provide the spaced terminal regions. Insulated electrical leads are then welded to the metal pattern to provide a desired interconnection configuration. Then the terminal regions and the insulated wires are covered with a molded plastic which encapsulates the wires and covers the metal pattern except where the metal is next adjacent the carrier. Following stripping of the carrier from the metal pattern, circuit components can be welded to the exposed portions of the metal pattern to complete an electronic circuit or network. The carrier can comprise a plate and a parting layer on the plate, the terminal regions being adhered to the parting layer and the carrier separated from the matrix by dissolving the adhesive.

The invention also provides a method of manufacturing a double sided circuit board comprising forming separate pluralities of spaced electrically conductive regions on and having surface areas next adjacent, faces of two respective carrier parts and selected terminal regions on each carrier part are interconnected by electrical leads having individual electrically insulating coverings. An electrically insulating layer is then placed over the electrical leads and the terminal regions on at least one of the carrier parts. The two carrier parts are then placed face-to-face with the electrical leads and the terminal regions sandwiched between the carrier parts. Electrically insulating material is then applied between the carrier parts to form a matrix enclosing the leads and the said insulating layer and in which the terminal regions are partially embedded. The carrier parts are then separated from the matrix to leave exposed on opposite surfaces of the matrix, surface areas of the terminal regions previously next adjacent the respective carrier parts. In a specific embodiment, the carrier parts are hinged together and following formation of the terminal regions and the interconnections, one carrier part is swung to locate it over the other carrier part, the two parts being separated by the previously mentioned layer of insulating material.

The terminal regions can include feed-through conductors having tab areas exposed at a surface of the matrix.

By way of example, embodiments of the invention will be described in greater detail with reference to the accompanying drawings, in which:

Figure 1 is an exploded perspective view illustrating a step in manufacturing a circuit board according to one embodiment of the invention;

Figures 2-6 are enlarged sections illustrating changes that occur during manufacture of a circuit board;

Figure 7 is a fragmentary perspective view illustrating the completed circuit board with an electronic component connected to the board;

Figures 8 and 9 are views illustrating another method of manufacturing a circuit board according to the invention;

Figure 10 is an enlarged section showing a circuit board manufactured according to the method of Figures 8 and 9 with electronic components connected to the board;

Figure 11 is a section showing two types of preformed structures used for mounting components on a circuit board; and

Figures 12 and 13 are plan views of the preformed structures per se.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now to Figures 1-6 of the drawings, at 1 is shown an insulating plate or carrier or base strip used for supporting a thin sheet or layer 3 of weldable metal during fabrication of a circuit board according to this invention. The metal sheet 3 may be secured to the upper surface of carrier 1 in any suitable manner, such as by cementing with suitable adhesives. An intermediate sheet 5 of Mylar (Registered Trade Mark) plastic or other parting material may be sandwiched between carrier 1 and sheet 3 to provide a parting surface or parting area A between sheet 3 and plate 1. Figure 2 shows three such layers cemented together. The adhesive used for securing these layers together is one which is easily removed by a solvent when the metal layer 3 is separated from carrier 1 and sheet 5, as described later. When a parting layer such as 5 is provided, there is less chance that the solvent used for separating the carrier will attack the other parts. The metal layer 3 is preferably a weldable metal that resists corrosion and can be etched to form a pattern of conductive lands. Kovar (Registered Trade Mark) or nickel foil having a thickness of about 0.002 to 0.005 inch have been found satisfactory. Materials used for the carrier 1 may vary considerably and include an inexpensive type of paper board or phenolic resin which is capable of withstanding the various operations required by the process. Thus it must be able without deforming to withstand the bonding of the layer 3 and process steps described later including etching, welding and molding. The material selected for carrier 1 will depend in part on whether the carrier is to be discarded after a single use or whether it is to be reused.

The upper surface of the metal sheet 3 is coated with a layer of a substance 7 (Figure 3) such as a photoresist which, when exposed to light, will undergo a photochemical change. Only selected portions of the photoresist are exposed so that a pattern of lands may be developed from the metal sheet 3 in the conventional manner.

In order selectively to expose portions of the photosensitive substance, so-called art work is used which comprises a plurality of standard patterns fitted together. One standard pattern may be of a shape to expose an area corresponding to the contact strip for mating with the plugs of a standard printed circuit board. Other patterns may expose land areas suitable for welding to the leads of integrated circuit flat packs. The designer of the circuit board selects the patterns which give him the number and arrangement of contacts and lands for the components or networks to be included in the circuit. These individual patterns are then taped together to form the final art

work, which is placed over the photosensitive substance 7, and the unshielded areas are then exposed to light to produce the usual photochemical reaction. Then the carrier 1, parting sheet 5, metal 3 and substance 7 are exposed to an etching solution to remove the portions of layer 3 beneath the unexposed areas of substance 7. As shown in Figure 4, this leaves a series of conductive lands or contacts, designated 9, on the parting sheeet 5. If desired, the pattern may be such that there are holes 11 in certain of the lands to provide for through holes in the resulting final circuit board.

Then the desired circuit is further developed on the lands, using insulated weldable wire conductors 13 (see Figure 5, for example). The welding of conductors 13 to the lands is in accordance with a previously prepared point-to-point wiring list based on a position code and standard integrated circuit numbering procedures arrived at during the design phase. It will be understood that in order to simplify this disclosure there has been no attempt in the drawings to illustrate any particular wiring diagram or circuit, there being a large number of possibilities in this regard.

The wire 13 used in developing the pattern as described above is weldable and flexible. It should have a high conductivity and is preferably covered with an insulation which can be easily removed or stripped away for baring an end of the wire to weld it to the lands 9. The wire insulation should be one which will not degrade or deteriorate during the molding process described later. Nickel wire or ribbon coated with an insulating material which is stripable when heated is suitable here. After the wires are welded, the circuit is visually inspected for weld integrity and proper layout.

The lands 9 and wires 13 are then covered with a suitable moldable embedding plastic material such as a fiberfilled epoxy resin. The plastic when cured forms a circuit board base or matrix support for lands 9 and is generally designated 15 (Figure 6). The plastic may be applied while the carrier 1, parting sheet 5 and lands 9 are in a suitable mold (not shown). The plastic material of base 15 encloses the top and side faces of the lands 9, and the wires 13 become completely embedded or enclosed in the material 15. The material 15 may be molded to a thickness slightly greater than the desired final thickness and then belt-sanded to the desired thickness, but preferably would be molded to the desired final thickness. When closed molds are used in forming the base 15, the belt-sanding step can be eliminated. Holes 17, coaxial with holes 11, can be molded in the base 15 for passing conductors or other elements through the board. Or the holes 17 may be routed or drilled subsequent to the molding step. One only of each of holes 11 and 17 is illustrated, it being understood that there may be more.

By using a suitable solvent, the carrier 1 and parting sheet 5 are then separated from the plastic base 15. The solvent dissolves the cement securing plastic sheet 5 to carrier 1 and lands 9. The lands 9 are now partially encased in and held by the plastic base 15. The resulting circuit board is illustrated in Figure 7 of the drawings where part of a semiconductor network or other circuit component generally designated 19 is shown welded to the exposed surface of the lands 9.

The completed circuit board has a flat surface 21 comprising the base and the exposed flush surface of lands 9. The wires or conductors 13 are fully embedded in the plastic of the base 15. The various lands 9 are wholly separate from each other as shown in Figure 7, and they, together with the wires 13 and electronic components 19, form a circuit.

The process above described is particularly suited for manufacturing a board where the components 19 are to be mounted on a single side of the board. The method of the present invention also can be used for manufacturing circuit boards wherein components are to be mounted on both sides of the board.

Figures 8-10 illustrate manufacture of a two-sided or double-sided circuit board. In manufacturing a double-sided board, a pinged carrier generally designated 23 is used. It comprises sections 25 and 27, each of which comprises approximately half of the carrier. Lands 9 are formed on each of the carrier halves 25 and 27 and are connected by insulated conductors 13 in the manner described in connection with Figures 1-5, except that in this case the parting sheet 5 is omitted. Then a suitable insulating material 29 (shown as a sheet of fiber-glass fabric) is placed over the lands 9 and conductors 13 on one half of the carrier and that half of the carrier is swung about the hinge 31 connecting the carrier parts together to place the lands 9 on one half of the carrier adjacent to the lands on the other half of the carrier. The lands on the carrier parts are separated by the insulating sheet 29. This is the position of the parts illustrated in Figure 9 of the drawings. Then the space between the carrier halves 25, 27 is filled with a moldable plastic material to provide a base 33 for the circuit board. The material comprising base 33 flows around three sides of each of the lands 9, through the interstices of the fibre glass fabric 29 and embeds the conductors 13 in the base. Carrier 23 is then separated from the base 33 and lands 9. Then circuit components 35 (Figure 10) may be positioned on one or

both sides of the board and welded to the lands 9 to provide the desired circuitry. It will be understood that circuit interconnections can also be made through holes in the circuit board.

The circuit board shown in Figure 10 has two substantially flat surfaces 37 and 39 generally parallel to one another and at said surfaces the metal elements or lands 9 are exposed. Other portions of the metal elements are embedded in the base. The glass cloth 29 remains in the base 33 and acts as a reinforcing and insulating member. It will be understood that glass cloth or other reinforcing material can also be provided in the plastic base 15 of the previously described embodiment of Figures 1-7.

Referring now to Figures 11-13, conventional components for circuitry can be mounted on the circuit boards of the invention using preformed feed-through conductor sructures. One of these structures is generally designated 41 in Figures 11-12 and comprises an electrically insulating circular body member 43 having three spaced tubular conductors 45 extending through it. There are tabs or feet 47 attached to the lower ends of each of these tubular members 45 and they are glued to the carriers 1 or 23 immediately after the etching step which produced the series of lands 9. Insulated conductors 50 can be welded to tabs 47 prior to molding the base so that they are embedded in the base as shown. When the base 49 (equivalent to 15 in Figure 7) of the circuit board is molded, the body portion 43 and the tubular members 45 are fixed in the base so tha only the ends of the tubular portions 45 and the tabs 47 are exposed at the surface of the plasic base. The leads of conventional components can then be welded to the tubular portions 45 and the feet 47 to effect desired circuit connections.

Another preformed feed-through conducor structure is generally designated 51 in Figures 11 and 13. It comprises a flat rectangular electrically insulating body portion 53 which is embedded in the base 49. A pair of conductive tubular members 55 project through the center portion. Tubular numbers 55 are molded in base 49 and extend entirely through the base. The lower end of the tubular members 55 have projecting tabs or feet 57 which are cemented to the carrier during manufacture of the circuit board immediately after the lands 9 are formed. The tabbed structure 51 (like the structure 41) eliminates the need for drilling operations to provide through-holes for connecting electronic components to the circuit.

Due to the high-speed capabilities of semiconductor networks it may be desirable to provide for some type of transmission line characteristics within the molded board. This may be accomplished by the use (instead of a single conductor) of twisted or parallel pairs of insulated conductors for signal paths with one of the two wires fastened to the signal terminal and the other to ground. The two wires can be insulated and twisted or simply molded in side-by-side relation but electrically separated. Also, a thin metal foil, screen or wire mesh may be molded into the plastic for the same purpose being insulated from the circuitry and grounded. Another way the desirable transmission line characteristics could be provided is to mold in a conductive material as a so-called electrical ground plane. This would be done by spraying an insulation material over appropriate lead wires and lands. A thin layer of conductive plastic or paint could then be molded over this insulation material. The board can be molded or finished as above described.

As various changes could be made in the above constructions and methods without departing from the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

WHAT WE CLAIM IS:—

1. A circuit board comprising a matrix of insulating material having a plurality of spaced electrically conductive terminal regions parially embedded therein with surface areas of the terminal regions exposed at a common surface of the matrix, and electrical leads enclosed in the matrix, the leads having individual electrically insulating coverings and interconnecting selected ones of the terminal regions.

2. A circuit board comprising a matrix of insulating material having a plurality of spaced electrically conductive terminal regions partially embedded therein with surface areas of some of the terminal regions exposed at one surface of the matrix and and the surface areas of other terminal regions exposed at an opposite surface on the matrix, and elecrical leads enclosed in the matrix which leads have individual electrically insulating coverings and interconnect selected ones of the terminal regions.

3. A circuit board according to Claim 2, including a discrete insulating layer embedded in the matrix between the terminal regions exposed at one surface and the terminal regions exposed at the opposite surface of the matrix.

4. A circuit board according to Claim 1 or Claim 2, including an electrical ground plane embedded in the matrix and electrically insulated from the leads and terminal regions.

5. A circuit board according to any one of the preceding claims, in which at least some of the terminal regions have exposed

surfaces co-planar with the surface of the matrix at which they are exposed.

6. A circuit board according to any one of the preceding claims, in which at least some of the terminal regions comprise feed-through conductors extending through the matrix and having tab areas exposed at the said surface or one of the said surfaces of the matrix.

7. A circuit board according to any one of the preceding claims, in which the electrical leads have been welded to the terminal regions.

8. A circuit board according to any one of the preceding claims, and having circuit components electrically attached to the exposed areas of at least some of the terminal regions.

9. An electrical circuit board substantially as described herein and as illustrated by FIGURE 7 of the accompanying drawings.

10. A circuit board substantially as described herein with reference to and as illustrated by FIGURE 10 of the accompanying drawings.

11. A method of manufacturing a circuit board, comprising forming a plurality of spaced electrically conductive terminal regions on a surface of a carrier with a surface area of each terminal region next adjacent the said surface of the carrier, connecting electrical leads having individual electrically insulating coverings between selected terminal regions, applying electrically insulating material to enclose the electrical leads and to cover the surfaces of the terminal regions not contiguous with the carrier and the remaining portion of the said surface of the carrier next adjacent the terminaly regions to form a matrix enclosing the leads and in which the terminal regions are partially embedded, and separating the carrier from the matrix to leave exposed the surface areas of the terminal regions previously next adjacent the said surface of the carrier.

12. A method according to Claim 11, the carrier comprising a plate and a parting layer on the plate, and the terminal regions being adhered to the parting layer, and in which the carrier is separated from the matrix by dissolving the adhesive.

13. A method of manufacturing a circuit board, comprising forming separate pluralities of spaced electrically conductive terminal regions on, and having surface areas next adjacent, faces of two respective carrier parts, on each carrier part interconnecting selected terminal regions with electrical leads having individual electrically insulating coverings, placing an electrically insulating layer over the electrical leads and the terminal regions on at least one of the carrier parts, placing the two carrier parts face-to-face with the electrical leads and the terminal regions sandwiched between the carrier parts, and applying electrically insulating material between the carrier parts to form a matrix enclosing the leads, and the said insulating layers and in which the terminal regions are partially embedded, and separating the carrier parts from the matrix to leave exposed on opposite surfaces of the matrix, surface areas of the terminal regions previously next adjacent the respective carrier parts.

14. A method according to any one of claims 11-13, in which the plurality or each plurality of terminal regions is formed by applying a conductive foil to the said surface of the carrier, applying an etch-resist pattern to the foil, and etching through the foil to the carrier in regions of the foil not protected by the etch resist pattern.

15. A method according to any one of claims 11-14, in which the electrical leads are connected to selected terminal regions by welding portions of the electrical leads to those terminal regions.

16. A method according to any one of claims 11-15, further comprising placing feed-through connectors having end tabs on the carrier on on at least one of the carriers prior to application to the said insulating material whereby the through connectors are held in the matrix with areas of the tabs exposed.

17. A method of manufacturing a circuit board substantially as described herein with reference to FIGURES 1-6 of the accompanying drawings.

18. A method of manufacturing a circuit board substantially as described herein with reference to FIGURES 8-10 of the accompanying drawings.

19. A method according to Claim 17 or 18, modified in the manner described herein with reference to and as illustrated by FIGURES 11 and 12 of the accompanying drawings.

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3 SHEETS

COMPLETE SPECIFICATION

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SHEET 1

FIG. 1.

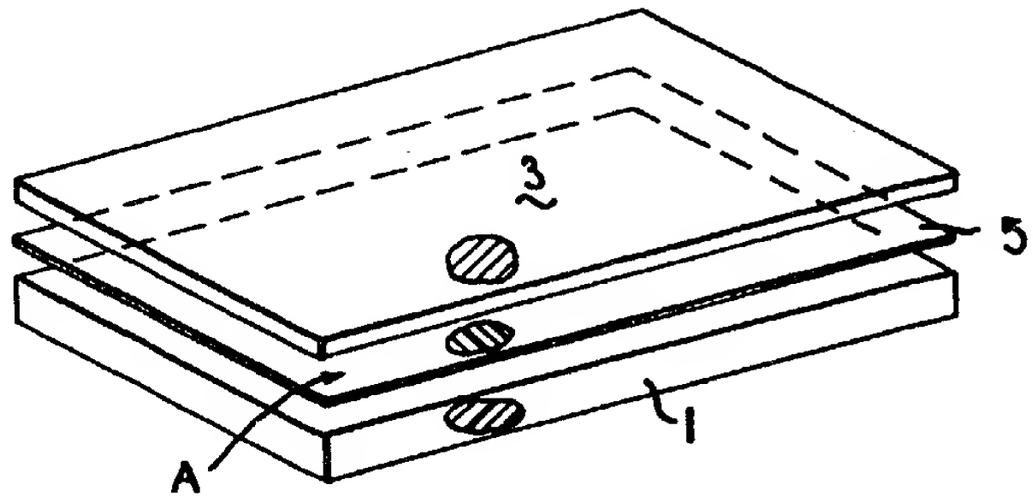


FIG. 2.

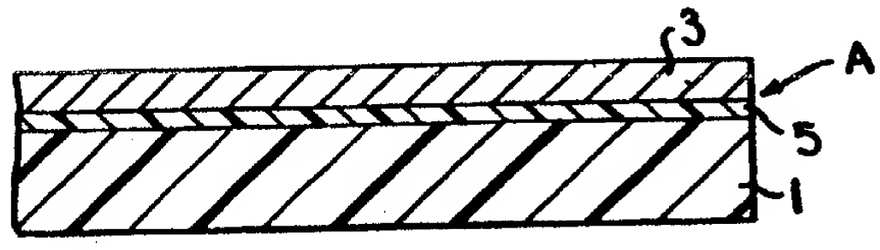


FIG. 3.

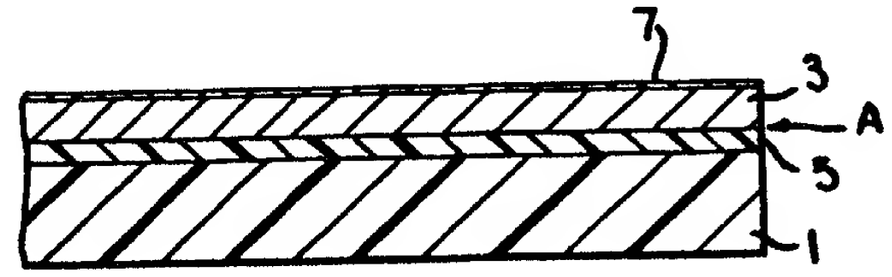


FIG. 4.

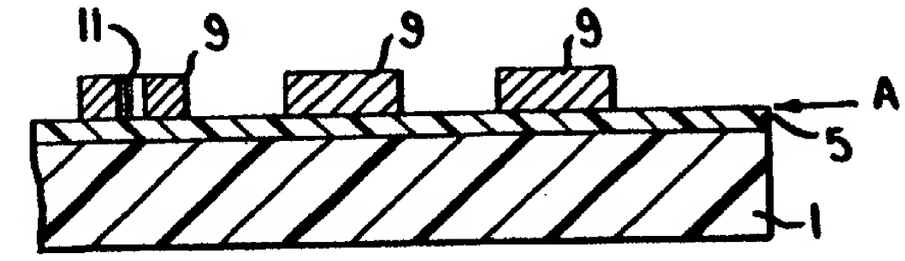
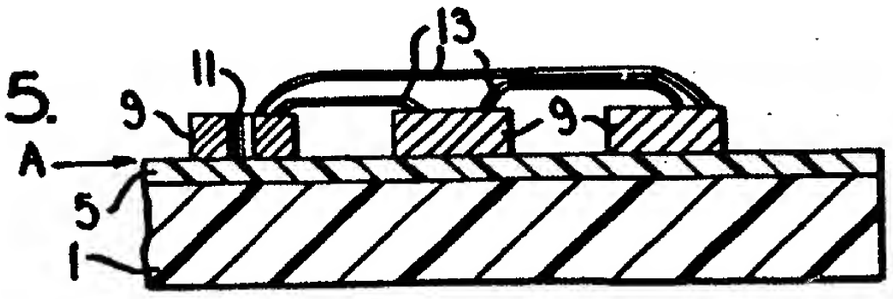


FIG. 5.



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SHEET 2

FIG. 6.

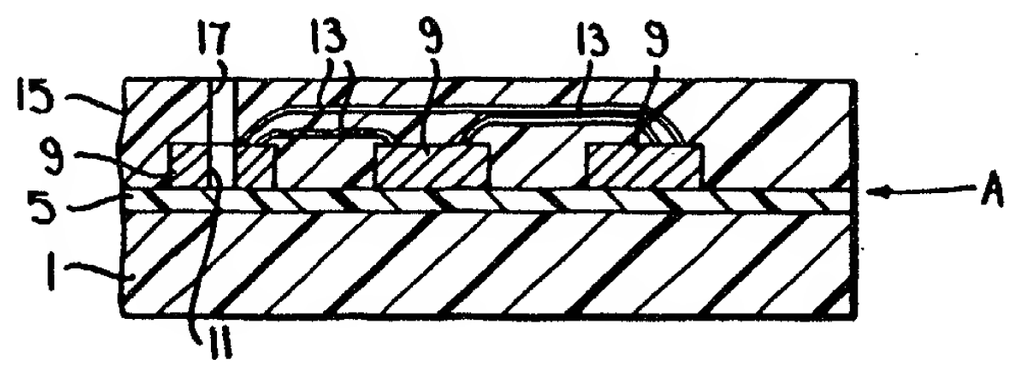

FIG. 7.

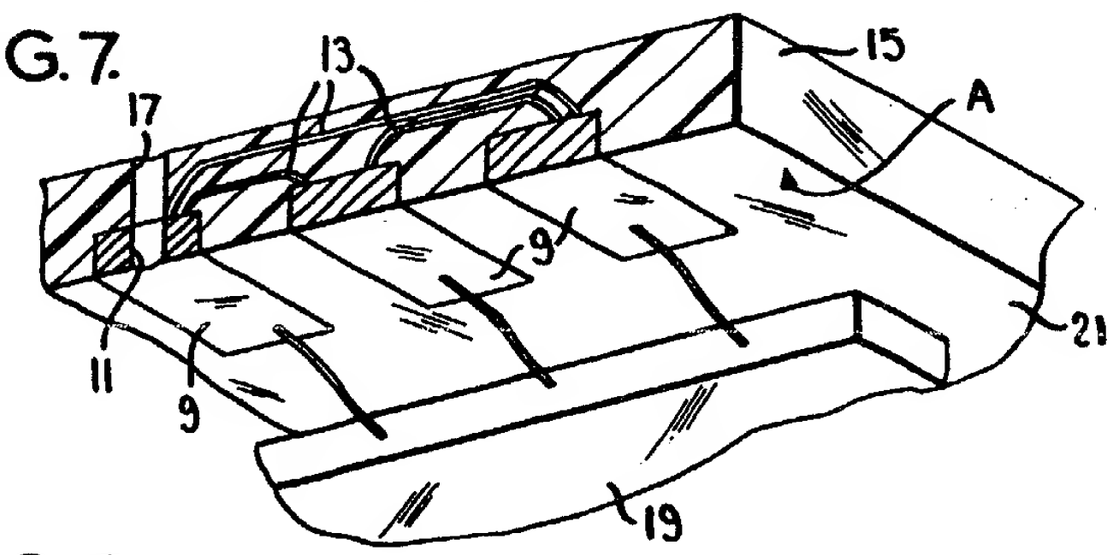

FIG. 8.

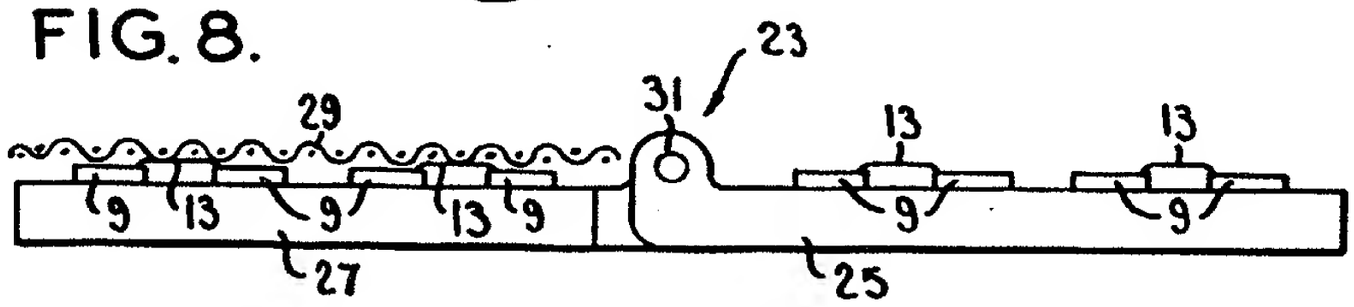

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FIG. 9.

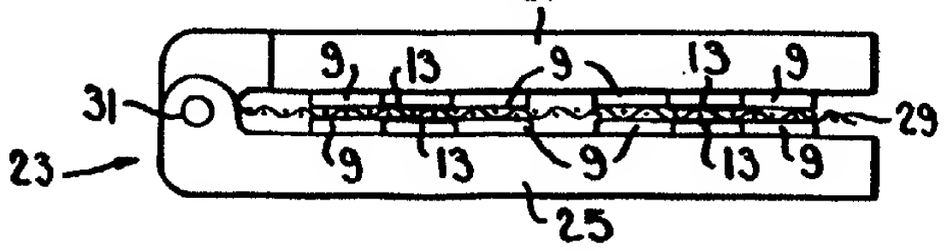
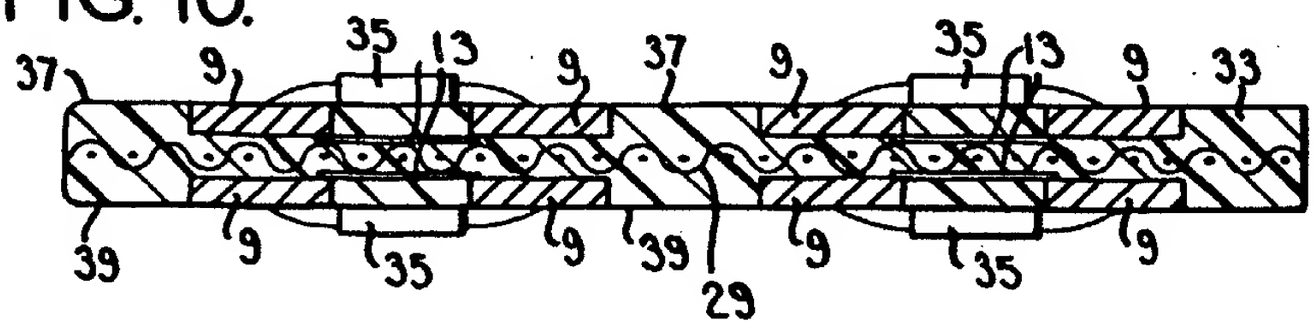


FIG. 10.



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SHEET 3

FIG. 11.

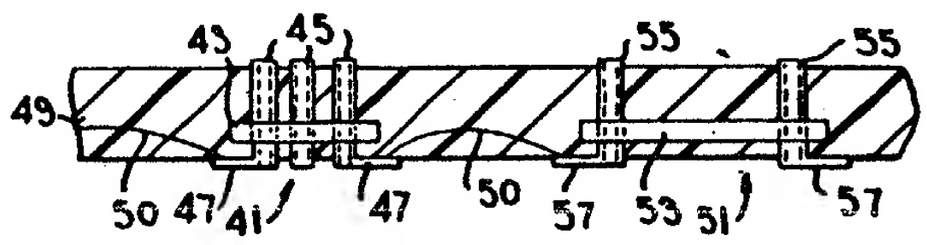

FIG. 12.

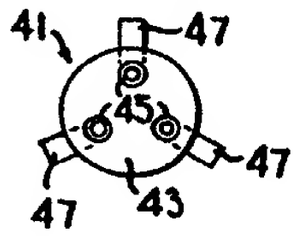

FIG. 13.